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New record of Chinese Reddish Mantis, *Hierodula chinensis* Werner, 1929 (Mantodea, Mantidae) from Japan

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Abstract

We report on a new distribution record of *Hierodula chinensis* Werner, 1929 from Gifu Prefecture, Honshu, Japan. This species is distributed in China and recently recorded from Korea. This is the first formal record of this species from Japan. Our comparison of the morphological characters of Japanese specimens with those of type specimens revealed that *H. chinensis* from Japan has dimorphic male genitalia and retains morphological diversity.

Keywords

Genital dimorphism, *Hierodula membranacea*, *Hierodula patellifera*, *Hierodula venosa*, *Titanodula formosana*

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Introduction

Praying mantises (Mantodea) are generalist predators and are important insects in natural ecosystems (Moran et al. 1996). Clarifying the fauna of Mantodea contributes to both taxonomy and ecology. *Hierodula* Burmeiser, 1838 is the largest genus in Mantodea, containing approximately 110 species (Zhu et al. 2012). More than half of the species in this genus are distributed in the oriental realm (Patel and Singh 2016; Liu et al. 2020). *Hierodula* is suggested to be paraphyletic with respect to the other genera and needs revision (Schwarz and Roy 2019), but this taxonomic problem has not been unsolved yet. In the past, *Hierodula patellifera* (Audinet-Serville, 1839) was the only species in this genus distributed in Japan (Patel and Singh 2016). However, we collected a species that belongs to the genus *Hierodula*, which has a distinctly different morphology from *H. patellifera*, in Gifu Prefecture, the central area of Honshu, Japan, in 2008. Fujino et al. (2010) also reported a female of the same putative species (as *Hierodula* sp.) collected in Fukui Prefecture, which is located next to Gifu Prefecture. Although the identifications were inadequate and/or inaccurate, records resembling this species have been reported in several regions of Japan (e.g., Yoshitsuru 2013; Mano and Uno 2014 in Aichi Prefecture; Aiba 2015 in Tokyo; Ohgushi et al. 2015 in Saga Prefecture).

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In the present study, we conducted the field and museum surveys to identify *Hierodula* sp. in Gifu Prefecture in Japan, comparing their morphological characters with those of type specimens and the taxonomic literature. We have identified this species as *Hierodula chinensis* Werner, 1929, and report it here for the first time from Japan. *Hierodula chinensis* was originally thought to be endemic to China, but then recently recorded in Korea (Shim et al. 2021). We also report on dimorphism of male genitalia in Japanese *H. chinensis*.

Methods

We collected the specimens reported here in the field in Gifu City, Gifu Prefecture, Japan (Fig. 1). The specimens were captured using an entomological net (Shiga Konchu Fukyusha, Tokyo, Japan). They were packed in entomological envelopes individually and taken to a laboratory of Gifu University. The specimens were compared with the holotype and paratype specimens of *H. chinensis* and the descriptions by Liu et al. (2020). The male genitalia were dissected according to Battiston et al. (2010). Morphological terminology for male genital structures follows Klass (1997) and Schwarz and Roy (2019), and that for the other body structures follows Brannoch et al. (2017). We also surveyed the Mantodea collection of the Nawa Insect Museum (NIM) in Gifu City, Gifu Prefecture, Japan. The oldest specimen showing the distribution of *H. chinensis* in Gifu Prefecture was deposited at NIM.

Results

We collected five adults (two females and three males) during the field surveys in 2008 and 2010 (Fig. 2A–F) and found a specimen (one male) captured in 2003 preserved in NIM (Fig. 2D). All the specimens were identified as *H. chinensis*. This is the first record of this species from Japan, and the third record in a country after China and Korea.

Family Mantidae Latreille, 1802
Subfamily Hierodulinae Brunner de Wattenwyl, 1893
Tribe Hierodulini Brunner de Wattenwyl, 1893
Genus *Hierodula* Burmeiser, 1838

***Hierodula chinensis* Werner, 1929**
New English name: Chinese Reddish Mantis

Material examined. JAPAN – Gifu prefecture • Gifu city; 35°25′60.0″N, 136°46′23.1″E, 38 m alt.; IX.2003; T. Nawa leg.; 1 ♂, Hc004 • ibid; IX.2008; T. Nawa leg.; 1♀ 1 ♂, Hc003 and Hc002 • ibid; IX.2010; T. Nawa leg.; 1 ♂, Hc001 • ibid; X.2010; K. Yamasaki leg.; 1♀ 1 ♂, Hc005 and Hc006. CHINA – Szetschwan province • Tatsienlu city; 1928; W. Stötzner exp.; 1 ♂, holotype – Peking • Westberge; 1928; W. Stötzner exp.; 1 ♂, paratype, Hc001-003, Schütte's personal collection; Hcoo4, deposited in NIM; Hc005-006, Yamasaki's personal collection; holotype and paratype, deposited in the Staatliches Museum für Tierkunde Dresden (SMTD), Dresden, Germany.

Identification. The specimens were identified based on the keys and descriptions by Werner (1929) and Liu et al. (2020), and the morphology of male genitalia was compared with the holotype and paratype specimens preserved in SMTD (Fig. 3A). All specimens were identified as *H. chinensis*. Pronotum length is 3.1–3.3 times the maximum width; edge of the widest point of the pronotum is not robust, rounded outside, and slowly narrows until the edges become parallel. Metazone is 2.8–3.4 times as long as prozone. Ventral margins of pro-, meso-, and metathorax reddish. Male genitalia: ventral phallomere: slightly curved lateral secondary distal process (sdpl) is thick at the base and slowly thin out to the

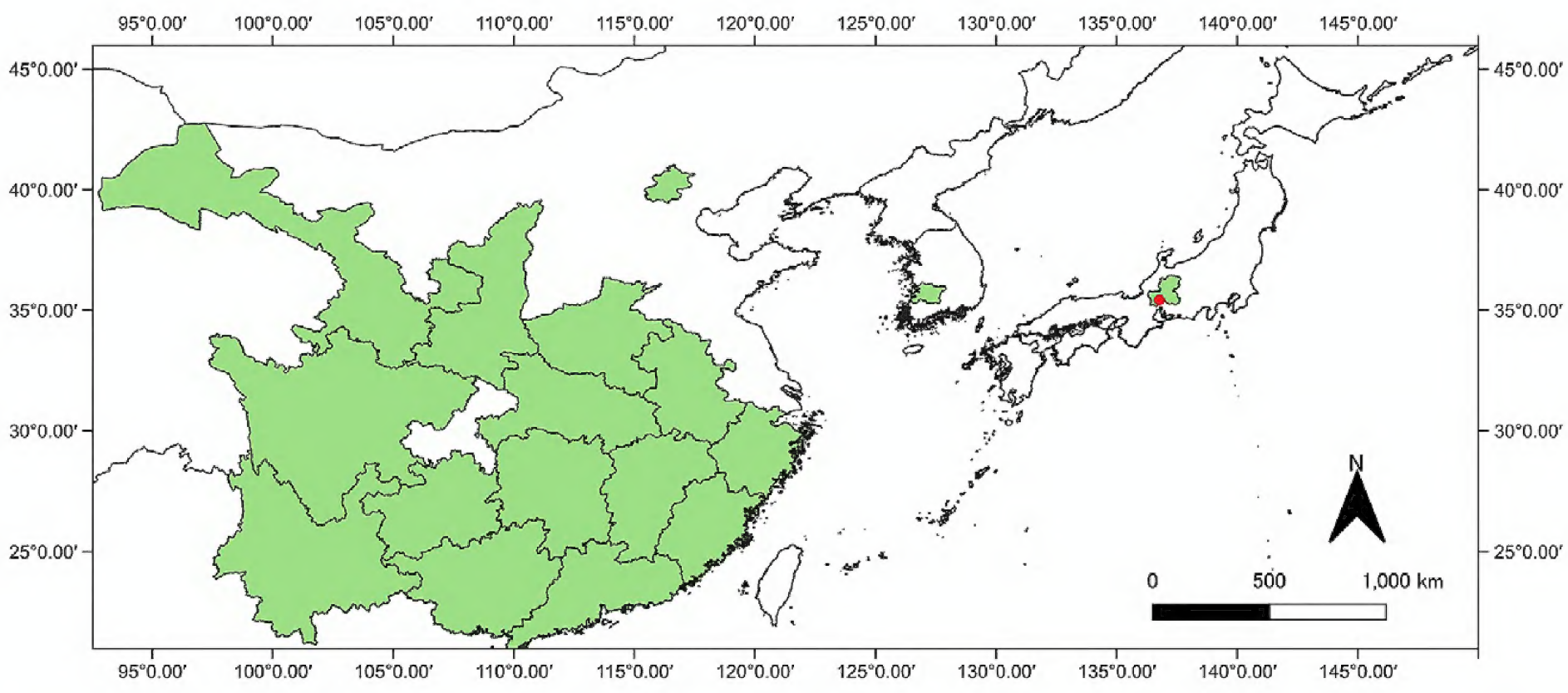

Figure 1. Collection point (red circle; 35°25′60.0″N, 136°46′23.1″E) in Gifu City, Gifu Prefecture, Japan and known distribution ranges (green coloration) of *Hierodula chinensis*. The range shown in China and Korea is based on Liu et al. (2020), Wang et al. (2020), and Shim et al. (2021). Coastlines and boundaries were obtained from the Database of Global Administrative Areas (https://gadm.org/).

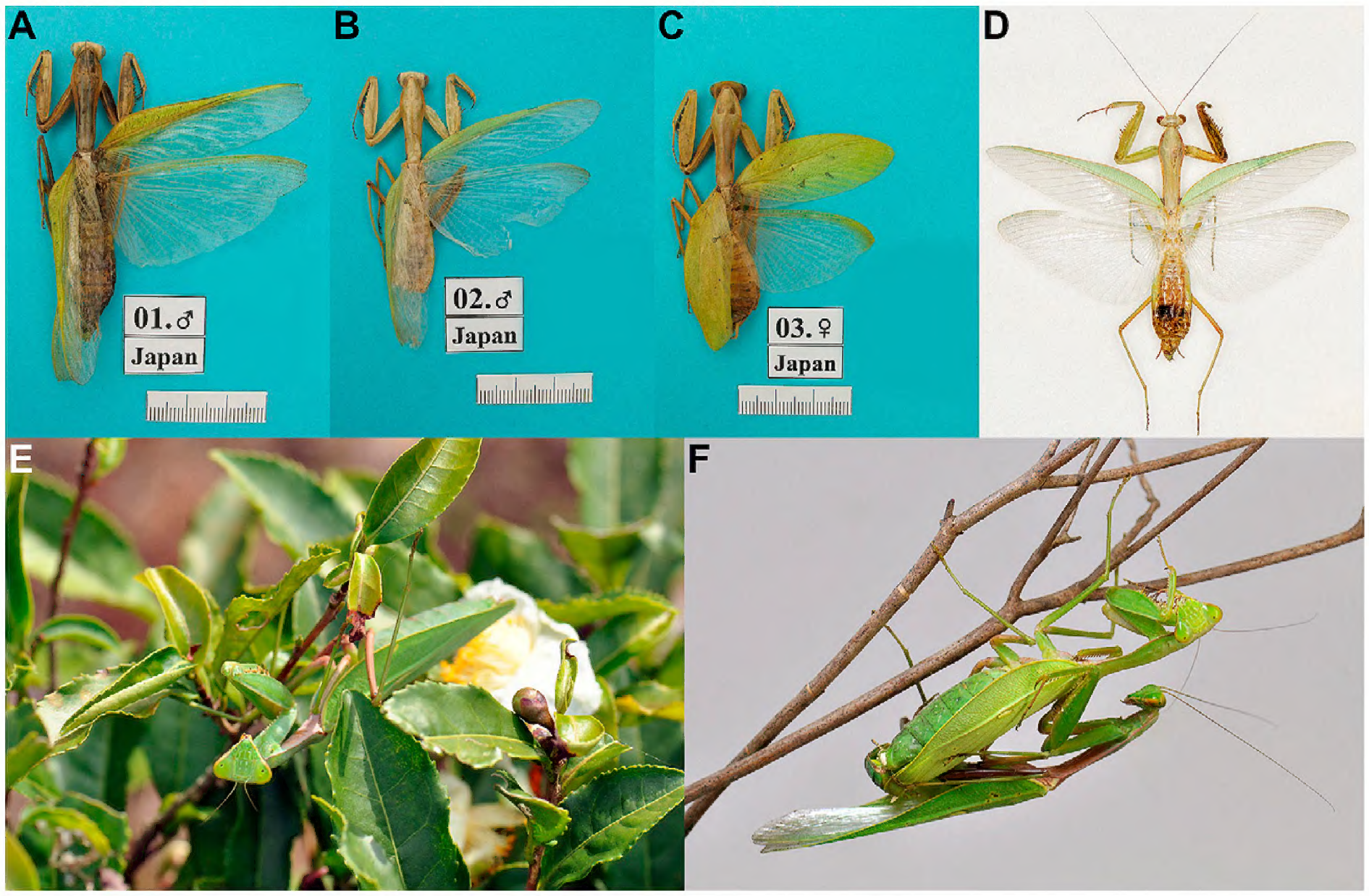

Figure 2. Specimens and ecological photograph of Japanese *Hierodula chinensis*. **A–C.** Collected in 2008–2010. Schütte's personal collection (© R. Ehrmann 2011). **D.** Collected in 2003 (NIM). **E.** Female in the bush of natural habitat (taken in 2010). **F.** Female and male in mating posture (taken in 2010).

apex. Only sdpl is present (genital type I) or both sdpl and elongated median secondary distal process (sdpm) are present (genital type II). Left phallomere: posterior process (pafa) is almost straight, and its apex suddenly becomes thin and sharp (Fig. 3B–E).

Remarks. The forewing costal margin lacks crenulations. The tip of the forecoxa lacks a black spot. These missing (field) characters distinguish the species from *H. venosa* and *Titanodula formosana*.

Discussion

These are the first formal records of *Hierodula chinensis* from Japan. The specimens we obtained in this study were all identified as *H. chinensis*. Our survey at NIM has revealed that this species has been present in Gifu Prefecture since at least 2003.

We clarified that Japanese *H. chinensis* has genital dimorphism (genital type I and II). This dimorphism

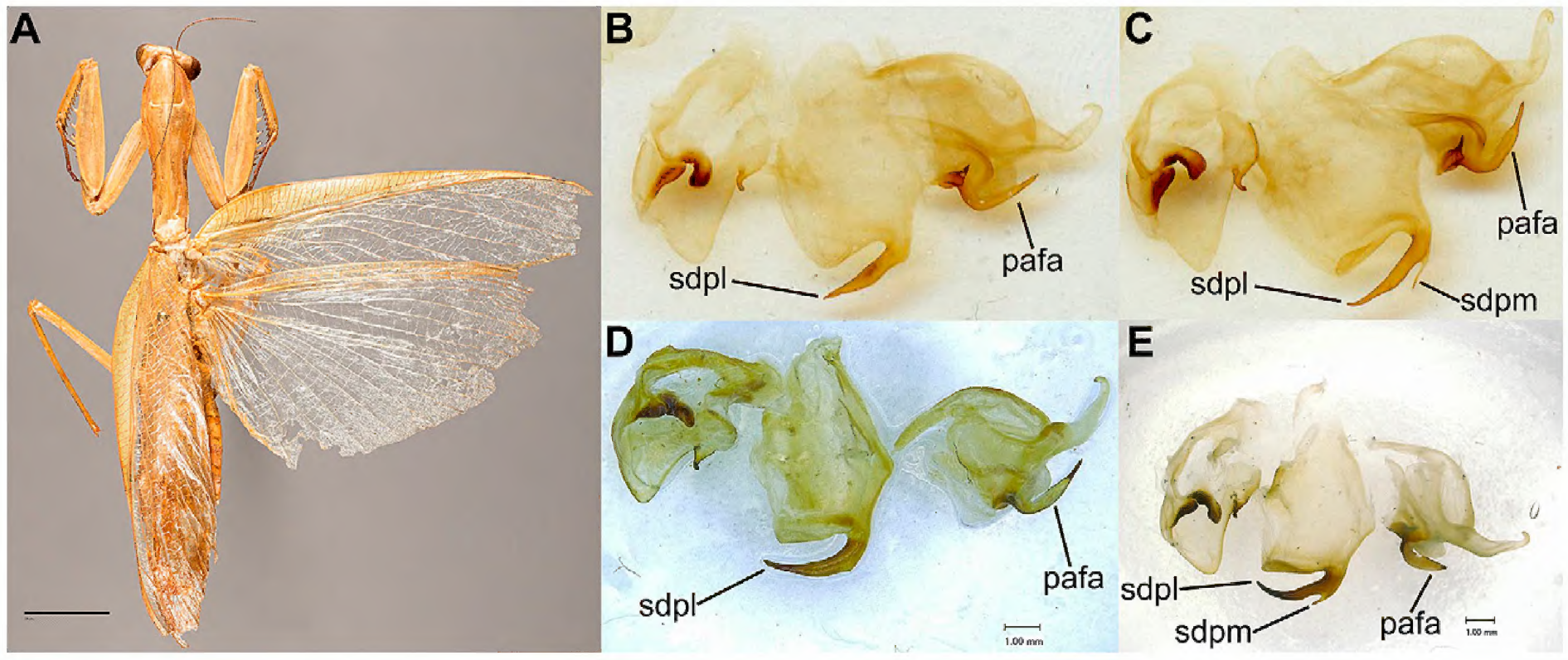

Figure 3. Male genitalia of Japanese *Hierodula chinensis* and its dimorphism comparing with type specimens. **A.** Holotype specimen (SMTD). **B.** Genital type **I**: Sdpm is absent (holotype). **C.** Genital type **II**: Elongated sdpm is present (paratype). **D.** Genitalia of Hc001 (Genital type **I**). **E.** Genitalia of Hc002 (Genital type **II**). Note that apex structure of pafa of this specimen is broken.

was also confirmed in the type specimens of this species: the holotype specimen has type I genitalia, and the paratype specimen has type II genitalia. Wang et al. (2020) also reported this genital dimorphism in Chinese *H. chinensis*. Our finding is the first report of *H. chinensis* from outside of China having dimorphic male genitalia.

Recently, there have been many reports about unidentified "reddish ventral thorax" *Hierodula* mantid species collected in various parts of Japan and thought to be *H. chinensis*, (e.g., Fujino et al. 2010; Yoshitsuru 2013; Mano and Uno 2014). Some of them have been tentatively identified as belonging to the same group as *H. chinensis*, either *Hierodula membranacea* Burmeister, 1838 or *Hierodula venosa* (Olivier, 1792), or *T. formosana* (Giglio-Tos, 1912) using the reddish ventral thorax as an indicator.

The group of *Hierodula* with a reddish thorax and including a long pronotum like *H. chinensis* has several species in Asia (Liu et al. 2020, 2021); all have similar external morphology. Therefore, the *Hierodula* species with a reddish thorax, which is rapidly being reported in many parts of Japan, should not be identified as *H. chinensis* based on the limited characters of thorax color and forecoxal spines. These are not the decisive characters for species identification, although they may be used in determining whether a specimen is the same species as *H. patellifera* in countries where there are few mantis species, such as Japan.

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Authors' Contributions

Conceptualization: KY. Data curation: KY, KS, TN. Formal analysis: KY, KS. Funding acquisition: KY. Investigation: KY, KS, TN. Methodology: KY, KS. Project administration: KY. Resources: KY, TN. Supervision: KY. Validation: KS. Visualization: KS. Writing – original draft: KY. Writing – review and editing: KY, KS, TN.

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